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DEFENSE DISTRIBUTION REGION CENTRAL REGIONAL FREIGHT CONSOLIDATION CENTER SIMULATION

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OPERATIONS RESEARCH OFFICE

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DEPARTMENT OF DEFENSE
DEFENSE LOGISTICS AGENCY

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FOREWORD

This is an analysis to determine if the Defense Distribution Region Central (DDRC) Regional Freight Consolidation Center (RFCC) located at Defense Distribution Depot Memphis, Tennessee (DDMT) can accommodate increases in throughput and workload from expanding its local customer area to include pooled freight destined for the South Central RFCC region (Texas, Oklahoma, Kansas, and New Mexico).

We found three factors that significantly impact the flow of material through the RFCC. They are the pallet unitization workstation process times, the size of the pieces flowing through the RFCC, and the number of pieces placed on a pallet at the pallet unitization stations. Any problems encountered with the flow of freight through the RFCC caused by the unitization workstations can be accommodated by policy changes and should not hinder expanding the local customer area to include the South Central region. Piece size and number of pieces per pallet are not adaptable. Since the RFCC is still in its testing phase, accurate data is not available on these two factors. Actual piece size and number of pieces per pallet should be verified before a final decision is made to include the South Central RFCC region.

The study was conducted for the Defense Logistics Agency Materiel Management/Transportation Office (MMAT). I wish to thank Mr. Robert Clark, Organizational Management Branch, DDRC, for providing the processing times for the various RFCC workstations. I also wish to thank the following personnel of DDMT and DDRC for providing information on the RFCC operations: Carter Boxiley, John Daggett, Pam Gowdy, Alice Johnson, Joel Neugebauer, Althea Peoples, Harold Roach, Danny South, Sally Tuggle, and Eva Wade.

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EXECUTIVE SUMMARY

This is an analysis to determine if the Defense Distribution Region Central (DDRC) Regional Freight Consolidation Center (RFCC) located at Defense Distribution Depot Memphis, Tennessee (DDMT) can accommodate increases in throughput and workload by expanding its local customer area to include pooled freight destined for the South Central RFCC region (Texas, Oklahoma, Kansas, and New Mexico). This analysis only addresses the movement of freight and the processes critical to the flow of freight through the mechanized RFCC. Factors such as cost effectiveness, equipment malfunction, or indirect workload are not included.

A newly mechanized RFCC is established at DDMT. The potential exists to enlarge the area proposed to be served by the Memphis RFCC to include pooled freight to the South Central region. This is made possible by the new mechanization installed in the DDMT freight terminal and the overall defense drawdown.

A simulation model is used to determine if the DDRC RFCC can accommodate increases in throughput and workload by expanding its local customer area. The results of the simulation revealed three factors that significantly impact the flow of material through the RFCC. These factors are the pallet unitization work station process times, the size of the pieces flowing through the RFCC, and the number of pieces placed on a pallet at the pallet unitization stations. The unitization workstation times are flexible. Any problems encountered with the flow of freight through the RFCC caused by the unitization stations are adjustable through implementing policy changes and should not hinder plans to absorb the South Central region. The piece size and the number of pieces per pallet are inversely correlated with each other. The smaller the piece size, the more you can fit on a pallet and vice versa. With the RFCC still in a testing phase,

accurate data is not yet available for these two factors. Since these factors are not flexible, actual piece size and number of pieces per pallet should be verified before a final decision is made to include the South Central region.

Based on analysis of available data and sensitivity analysis with respect to the piece size and number of pieces per pallet, we offer the following recommendations:

(1) If the average piece size is 1 foot or less and the average number of pieces per pallet is greater than 10, we recommend including the South Central region as part of the RFCC local customer area.

(2) If the average piece size is 2 feet or greater and the average number of pieces per pallet is 5 or less, we do not recommend including the South Central region as part of the RFCC local customer area.

(3) If the average piece size is between 1 and 2 feet and/or the average number of pieces per pallet is between 5 and 10, we recommend that the simulation be rerun and that the results be used as a basis for determining whether the South Central RFCC region should be included as part of the RFCC local customer area.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SECTION 1
INTRODUCTION

The Defense Logistics Agency (DLA) Operations Research Office (DORO) was tasked by DLA Material Management/Transportation Office (MMAT) to determine if the Defense Distribution Region Central (DDRC) Regional Freight Consolidation Center (RFCC) located at Defense Distribution Depot Memphis, Tennessee (DDMT) can accommodate increases in throughput and workload by expanding its local customer area to include pooled freight destined for the South Central RFCC region (Texas, Oklahoma, Kansas, and New Mexico).

1.1 BACKGROUND

A newly mechanized RFCC is established at DDMT. The purpose of the RFCC is to accept freight from several sources. The freight is consolidated into large shipments based on the customer, and moved by commercial carrier to the final destination (see Figure 1-1).

Currently, there are three main sources of freight feeding the Memphis RFCC:

(1) Transshipment freight - freight that originates at other depots destined for the Mississippi Valley region (Kentucky, Missouri, Arkansas, Louisiana, Mississippi, Alabama, and Tennessee), DDMT's local service area.

(2) Host freight - freight that originates at DDMT destined to customers in the DDMT local service area (Mississippi Valley region) and to other RFCC regions.

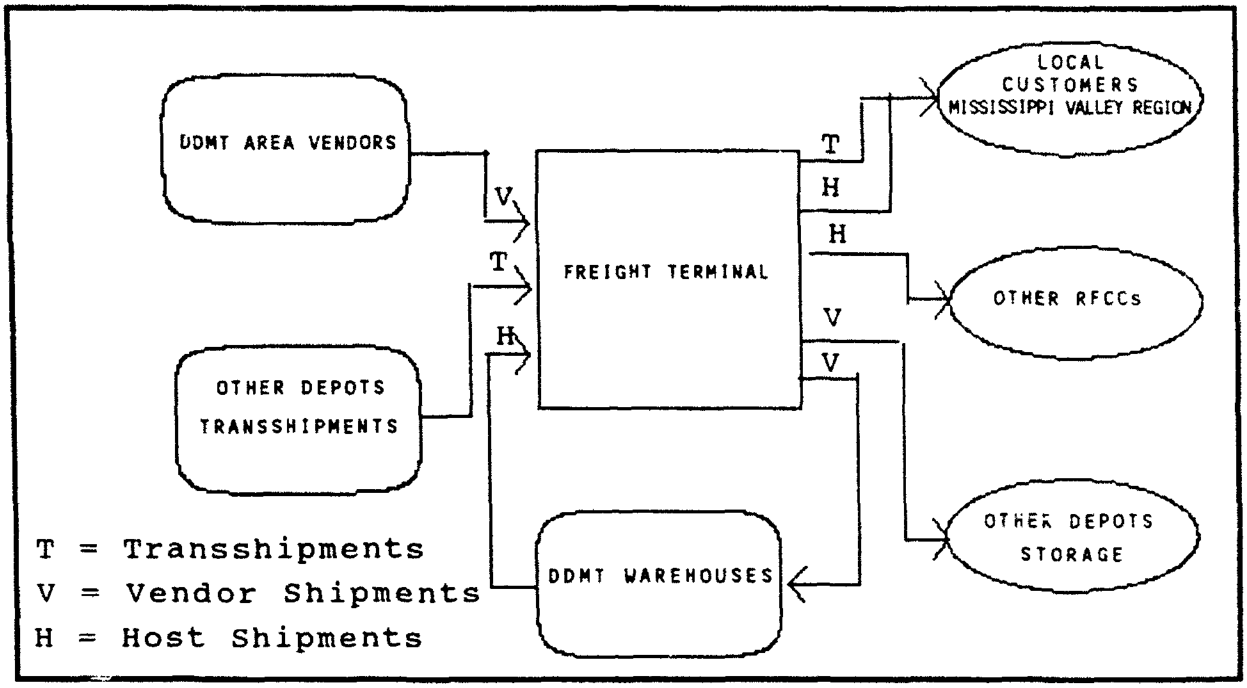

Figure 1-1. Current DDRC RFCC Freight Sources

(3) Vendor freight - freight that originates at vendor locations destined for various DLA depots.

A combination of transshipment and host freight is known as pooled freight. The potential exists to enlarge the area served by the Memphis RFCC to include pooled freight to the South Central region (Texas, Oklahoma, Kansas and New Mexico). This is made possible by the new mechanization installed in the DDMT freight terminal and the overall defense drawdown.

Expanding the DDMT local customer area to include the South Central region for pooled freight would serve to increase the transshipment volume (see Figure 1-2). Host and vendor shipment volumes would not increase.

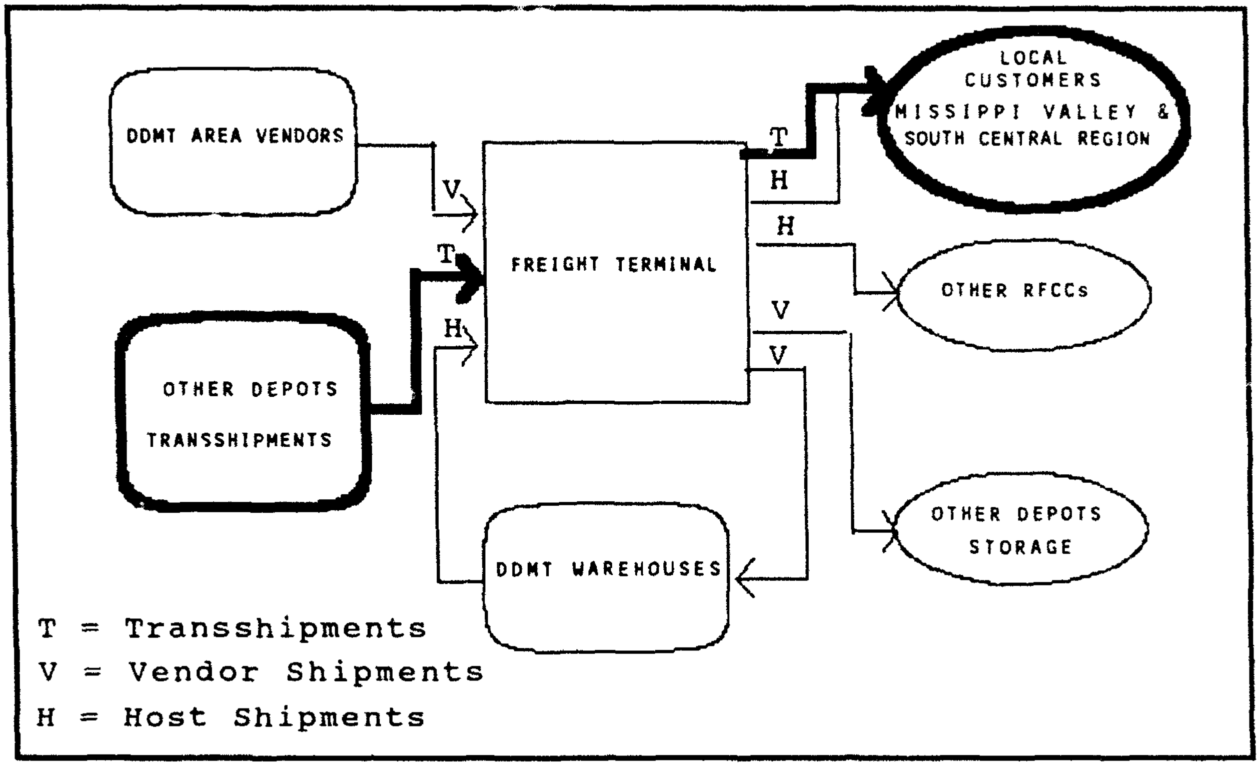

Figure 1-2. Proposed DDRC RFCC Sources

1.2 SCOPE

The following areas are covered within the scope of this analysis.

(1) Only processes internal to the RFCC freight terminal are examined. Processes which bring the freight to the terminal, be they inside or outside the depot, are not evaluated.

(2) Only vendor freight originating in the Mississippi Valley Region destined for storage at DLA depots is modeled. Vendor freight originating in the South Central RFCC region is under contract to a commercial

operator and is not planned for transshipment through the Memphis RFCC. Therefore, it is not evaluated.

(3) All transshipment freight destined for the Mississippi Valley and South Central regions, as well as, DDMT host freight are included in the model.

1.3 OBJECTIVE

The objective of the study is to determine if the mechanized DDMT RFCC can accommodate the workload increase associated with expanding the DDMT local customer area to include the South Central region.

1.4 ASSUMPTIONS

Following are the assumptions used to model the DDMT RFCC operation.

(1) The freight volume is reduced by 5 percent to account for the defense drawdown. This follows the expected reduction of 5 percent for all of DLA in 1992-1993 as budgeted by the DLA Comptroller. The 5 percent reduction is applied to all freight originating at Memphis as well as to transshipment freight from other depots.

(2) RFCC vendor participation is based on the average DLA rate for 1991 and 1992.

(3) Mechanical failure is not modeled.

(4) Pieces and pallets are assumed to enter the terminal steadily throughout the day rather than in surges.

(5) Arrival and unloading of trucks is not modeled.

(6) An 8 hour work day and 5 day work week is used for all freight. The daily number of pieces/pallets dropped in a day are assumed to be processed in the same day.

(7) Historical data is used to determine the daily amounts dropped at the RFCC. It is assumed that the implementation of the RFCC will not change these patterns.

(8) Only RFCC eligible freight is modeled.

(9) Fifty percent of the vendor and transshipment pieces require depalletization.

(10) Twenty five percent of the pallets would go to the band wrapper, 50 percent to one of the two shrink wrappers, and the other 25 percent, pieces not requiring special preparation, will bypass these stations.

1.5 LIMITATIONS

The following limitations apply.

(1) This analysis only addresses the movement of freight and the processes critical to flow of freight through the mechanized RFCC.

(2) Factors such as cost effectiveness, equipment malfunction, or indirect workload are not included.

SECTION 2
METHODOLOGY

A simulation model was developed to aid in determining if the DDMT RFCC is capable of handling the workload associated with expanding the local customer area to include the South Central region. The model evaluates the mechanized movement of freight through the terminal and the work station processes associated with the freight movement. There were two major steps critical to development of the model. The first was the analysis of the empirical data needed to set up the model and the second involved modeling the RFCC system operation. Data analysis included screening for RFCC eligibility requirements, formulating the input data, and making the lane assignments. RFCC system operation included modeling the package conveyor system, the pallet conveyor system, conveyor merge priorities, and the RFCC work stations.

2.1 RFCC SYSTEM OPERATION

Freight from all three sources was classified into two distinct types: pieces and pallets. Pieces are single cartons with a single destination. Pallets are multiple cartons, either in a triwall or on a pallet, with a single destination. Any pallets arriving at the RFCC containing multiple destinations are depalletized and sent through the system as pieces. How and where freight enters the RFCC system is determined by the type and the source of freight. Pieces are transported through the RFCC on a package conveyor system. Pallets are transported through the RFCC on a pallet conveyor system (see Figure 2-1).

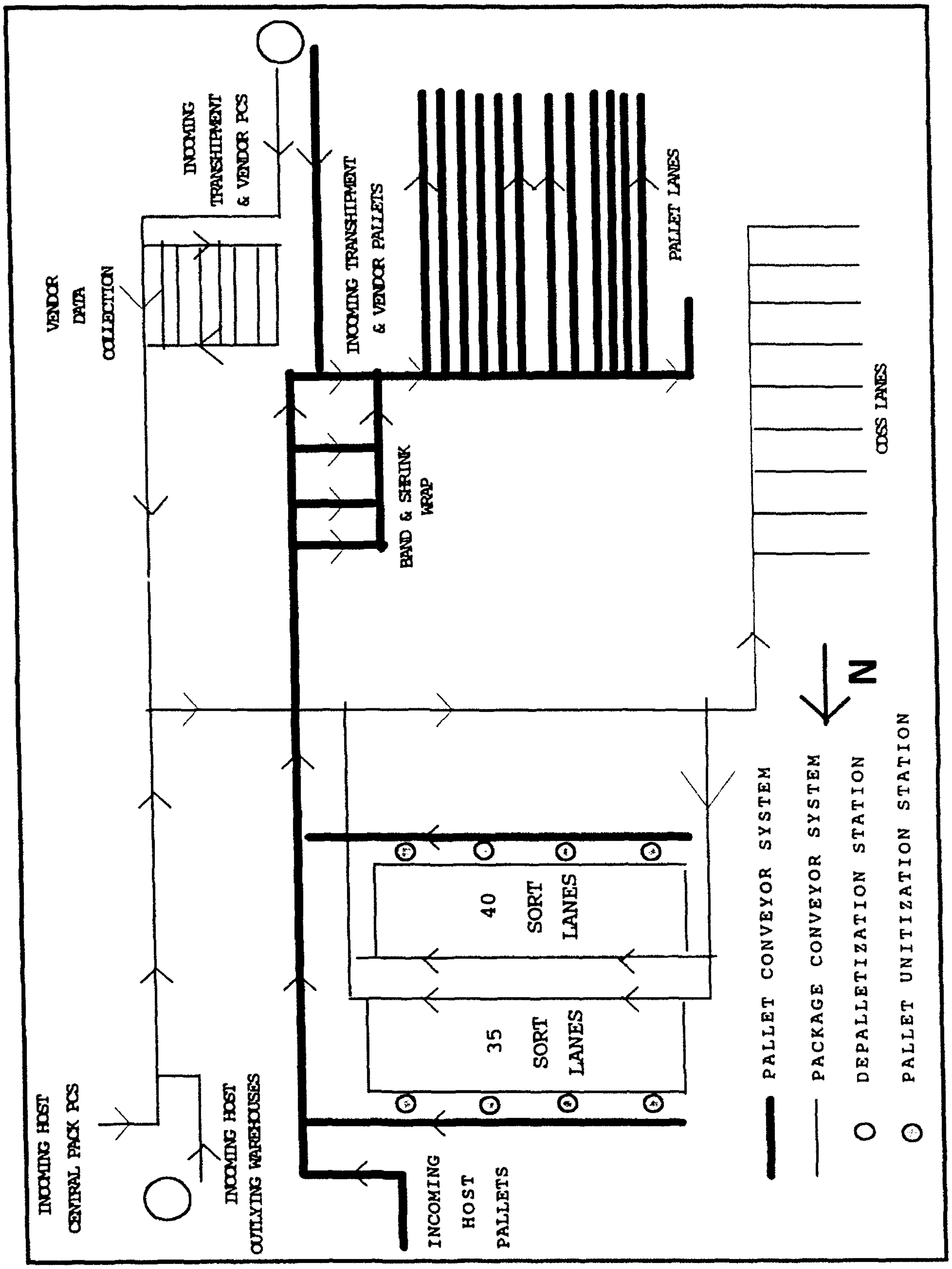

Figure 2-1. Freight Movement

2.1.1 PACKAGE CONVEYOR SYSTEM

Host pieces are placed on a package conveyor on the north side of the terminal and vendor and transshipment pieces are placed on a package conveyor on the south side of the terminal. Pallets containing packages with multiple destinations must be processed as pieces. These pallets are unloaded at a depalletization station in the area where they are received. Each piece is then scanned prior to being placed on the package conveyor. Once a piece is scanned and recognized by the DLA Warehousing and Shipping Procedures (DWASP) computer, it is given a routing assignment through the RFCC, based on its final destination.

When vendor pieces arrive at the RFCC, they are not in the DWASP system. Each vendor piece must be labeled with a bar scan label and placed on the package conveyor. Vendor pieces move to a data collection station where they are entered into DWASP. All pieces merge on the package conveyor belt and are scanned by the OS2 scanner. The scanner then routes the piece to the package sort lanes or to the Carton Delivery and Staging System (CDSS). Which path the pieces take is based on the destination of the particular piece.

The sort lanes are reserved for pieces destined to high volume customers. High volume customers are determined by either the Destination Cross Reference (DCR), the Standard Point Location Code (SPLC), the Department of Defense Address Activity Code (DODAAC), or the Point of Embarkation (POE). Pieces routed to a sort lane are palletized at a pallet unitization station at the end of the lane. The pallet is then placed onto the pallet conveyor system. If a piece is unable to enter a lane due to a lane full condition, it reenters the package conveyor system prior to the OS2 scanner and recirculates until it is able to enter its designated lane. Any piece that is not given a sort

lane is diverted to the CDSS. What lane a piece takes on the CDSS is based on the destination state. Pieces are removed from the CDSS lanes and placed directly onto a truck.

2.1.2 PALLET CONVEYOR SYSTEM

Host pallets enter the pallet conveyor system on the north side of the terminal. Pallets created at the sort lanes (internal pallets) are transported from the pallet unitization station to the pallet conveyor by means of an Automatic Guided Vehicle (AGV). Host pallets and internal pallets merge and proceed to the shrink and band wrapping area where they are secured for shipment. From this point, the pallets proceed on the pallet conveyor system and merge with the transshipment and vendor pallets entering the pallet conveyor on the south side of the terminal. All pallets are scanned and weighed before proceeding to a pallet lane assignment. Pallet lane assignments are similar to the sort lane assignments. Pallets for high volume customers are assigned to one of the 12 pallet lanes. All other pallets are routed to the end of the pallet conveyor system and off-loaded by forklift for staging or direct truck loading.

2.1.3 CONVEYOR MERGE PRIORITIES

When conveyors merge, one conveyor has priority over the other. The merge priorities for the package conveyor system are (1) the data collection stations conveyor over the incoming transshipment conveyor, (2) the host conveyor over the vendor and transshipment conveyor, (3) the sort lane recirculation loop conveyor over the host, vendor, and transshipment conveyor. The merge priorities for the pallet conveyor system are (1) incoming host pallet conveyor over the sort lane conveyors, and (2) the internal and host pallet conveyor over the transshipment pallet conveyor.

2.1.4 RFCC WORK STATIONS

The workstations directly involved with the movement of freight through the mechanized RFCC are two depalletization stations (one for vendor transshipment freight and one for host shipments), six vendor data collection stations and eight pallet unitization stations. Times for the work stations were provided by the Organizational Management Branch of DDRC. These service times include work conditions such as breaks and the effects of personnel fatigue. All times have a variation of +/- ten percent. The times were obtained during the testing phase of the RFCC and are estimates; however, they are the most accurate data available on work station times. The RFCC system specifications and service times are listed in Table 2-1.

2.2 DATA ANALYSIS

The data for host and transshipment freight were derived from the depot Material Release Order (MRO) history files covering a 3-month time period from July 1992 through September 1992. The data for vendor shipments were provided by MMAT.

2.2.1 RFCC ELIGIBLE FREIGHT

Freight eligible for processing by the RFCC must meet certain requirements; likewise, the MRO history files used for the model were screened using the following criteria: (1) the weight of a piece must be greater than or equal to five pounds and less than or equal to 125 pounds, (2) the shipment mode code must equal A, B, S, T, N, V, I, K, 9, G, or 5, (3) the service code is not equal to C, E, L, Q or U, (4) the special requirements code is not equal to D or F, (5) the hazardous material compatibility code is equal " ", M1, or N1, (6) the water commodity code is equal to H, M, Q, Z, 3 or " " , and (7) the required delivery date is not equal to N, E, 777, 555 or 999.

Table 2-1. System Specifications And Service Times

Package Conveyor System	
Conveyor Speed	90 feet/minute
Spacing between pieces	3 feet
Pallet Conveyor System	
Conveyor Speed	30 feet/minute
Spacing between pallets	3 feet
Stretch & Band Wrapper	1.33 minutes/pallet
OS2 Scanner Hold Time	4.0 seconds/piece
Data Collection	
Conveyor Length	30 feet
Work Station Processing Times	11.4 seconds/piece
Sortation Lanes	
Conveyor Length	20 feet
Work Station Processing Times	35.37 seconds/piece
AGV Pallet Transfer Car	
Transfer Car Speed	250 feet/minute
Pallet Transfer Time	50 seconds
Depalletization Work Stations	
Vendor Depalletization	27.94 seconds/piece
Transshipment Depalletization	23.11 seconds/piece

2.2.2 INPUT DATA

Host and transshipment data were aggregated by origin depot and shipping unit (SU) number. If the total cube of the shipping unit was greater than or equal to 40 cube, the SU was assumed to move through the RFCC as a pallet. The total cube was divided by 40 to determine the number of pallets per SU.

The data were then aggregated by origin depot, drop day, and destination. Because DDMT dedicated truck shipments coming out

of central pack are consolidated onto pallets in central pack, 60 percent of the pieces destined to dedicated truck customers were assumed to move through the RFCC as pallets. Assuming 10 pieces per pallet, the additional number of pallets for dedicated truck customers was calculated as (.60 * number of pieces / 10) and the number of pieces for dedicated truck customers was recalculated as (.4 * number of pieces).

To determine the number of pieces and pallets from the three sources to input into the model, the data were grouped by source and drop day. The drop day was grouped by day of the week (Monday through Friday). A notched box plot analysis was performed on the number of pieces/pallets dropped on different days of the week to determine if there was a significant difference between the number of pieces/pallets. The results of the box plot showed that Monday's and Thursday's numbers were different than the other days of the week. The main reason is that dedicated truck shipments at Memphis are dropped on Monday and Thursday. Therefore, two groups of input numbers were developed to drive two different scenarios in the simulation. One scenario represented dedicated truck days and the other non-dedicated truck days. Table 2-2 lists the input numbers used in the simulation by source and type.

2.2.3 LANE ASSIGNMENTS

Three sets of lane assignment determinations were developed from a combined data set which merged the vendor data and the historical MRO data. The three lane assignments were made up of sortation lanes, CDSS lanes, and pallet lanes. The sortation lanes and CDSS lanes were derived from the number of pieces expected to flow through the package conveyor system. The pallet lane assignments were derived from the total number of pieces and pallets expected to flow through the system.

Table 2-2. Number Of Pieces/Pallets By Source And Type

Source & Type of Shipment	Dedicated Truck Days	Non-dedicated Truck days
Transshipment		
Pieces	1406.00	1270.00
Pallets	9.00	8.00
Host		
Pieces	2168.00	2448.00
Pallets	68.00	21.00
Vendor		
Pieces	2800.00	2800.00
Pallets	23.00	23.00

Assigning a sort lane for a particular piece involved the following four steps. First, the data were grouped by day over a 3-month period. DCRs were then ranked by the number of pieces by day. The ranked data were then grouped by category, category being either a dedicated truck day (Monday or Thursday) or non-dedicated truck day (Tuesday, Wednesday, or Friday) for the 3-month period. After the data were categorized, it was rank ordered by day. For example, the DCR with the most pieces on each of the 20 dedicated truck days in the period was placed in rank 1 of 70, the next highest 2 of 70 and so forth until 70 of 70 was reached. If a DCR was not one of the top 70 ranked DCRs for the day then the pieces were assumed to go to the CDSS. Second, the mean number of pieces by rank and category were calculated. Third, the mean number of pieces by rank and category for the top 70 customers were fit to a distribution. Finally, so that no one workstation received the top eight customers, the ranked data were assigned to a lane. (i.e. work-station #1 gets the customers ranked 2, 61, 55, 57, 64, 60, 56, and 54). See appendix A.

If a DCR was not ranked in the top 70 customers for any given day, that customer was assumed to be routed to the CDSS and given a CDSS lane assignment based on the destination state. The CDSS lanes were defined by the following destinations:

301	Texas, Oklahoma, New Mexico, Kansas
302	Arkansas, Missouri, Kentucky, Tennessee
303	Florida, Georgia
304	Alabama, Mississippi, Louisiana
305	North & South Dakota, Nebraska, Iowa, Minnesota, Wisconsin, Ohio, West Virginia, Michigan, Indiana, Illinois
306	Delaware, Washington DC, Maryland, Pennsylvania, New Jersey, New York
307	California, Oregon, Washington, Nevada, Vermont, Wyoming, Colorado, Montana, Idaho, Utah
308	North & South Carolina, Virginia
309	Error processing lane for any freight that gets routed to no other CDSS lane.

The CDSS lanes were grouped by day and category. The average number of pieces to flow to CDSS was computed for the 3-month

period and a probability was derived for each lane. See Table 2-3 for the CDSS lane probabilities.

The pallet lane assignments were developed based on the grand total number of pieces for each DCR. The grand total number of pieces was calculated as ((number of pallets * 10) + the number of pieces). Each DCR was ranked by day and given a lane assignment. There are 13 pallet lanes available. Any pallets not going to lanes 1 through 12 are routed to lane 13. The data were grouped by category and a probability was derived for each pallet lane. See Table 2-4 for the pallet lane probabilities.

Table 2-3. CDSS Lane Probabilities

	DEDICATED TRUCK DAYS	**NON-DEDICATED TRUCK DAYS**
SORTER	0.84	0.80
CDDS	0.16	0.20
301	0.20	0.22
302	0.14	0.11
303	0.08	0.10
304	0.16	0.14
305	0.07	0.14
306	0.06	0.05
307	0.09	0.10
308	0.07	0.04
309	0.14	0.10
TOTAL	1.00	1.00

Table 2-4. Pallet Lane Probabilities

PALLET LANE	DEDICATED TRUCK DAYS	NON-DEDICATED TRUCK DAYS
1	0.18	0.18
2	0.09	0.09
3	0.08	0.09
4	0.08	0.08
5	0.04	0.04
6	0.08	0.06
7	0.07	0.06
8	0.02	0.02
9	0.02	0.02
10	0.02	0.01
11	0.02	0.01
12	0.01	0.01
13	0.29	0.33
TOTAL	1.00	1.00

SECTION 3

FINDINGS AND CONCLUSIONS

The original throughput requirements of the RFCC were 2800 vendor pieces, 605 transshipment pieces and 3063 host pieces, making a total of 6468 pieces daily. Based on input numbers shown in Table 2-2 and the original throughput requirement numbers, it appeared that inclusion of the South Central region would not hinder the RFCC workload capacity. However, the most recent estimates of unitization workstation times have been increased from 32 to 35.37 seconds per piece (See Table 2-1). In addition, RFCC eligibility requirements eliminating freight under 5 pounds may prove the assumption of an average piece size of 1 foot to be too low. Accordingly, if the average piece size increases, then the average number of pieces on a pallet should decrease. Therefore, a sensitivity analysis was performed on these factors to determine the impact of the changes.

Five scenarios were run for both dedicated and non-dedicated truck days (see Table 3-1). In addition to the variable changes listed in Table 3-1, the number of pieces/pallets of vendor freight was reduced by 15 percent in scenarios 4 and 5. This reduction in vendor freight corresponds to similar reductions in host and transshipment freight due to a combination of restrictions on the package conveyor, which required the elimination of pieces less than five pounds and greater than 125 pounds (10 percent), and another 5 percent due to the military down sizing assumption.

The RFCC has a "clean floor" policy (all pieces are processed the same day they are received). Thus, the model was run as a terminating simulation with 20 iterations of each scenario. Because the RFCC operates on an 8 hour shift with an additional 4 hour skeleton crew to process any straggling freight, it is <u>imperative</u> that the simulation run time be close to 8 hours.

Table 3-1. RFCC Simulation Scenarios

SCENARIO	PIECE SIZE (FEET)	UNITIZATION PROCESS TIMES (SECONDS/PIECE)	NUMBER OF PIECES / PALLET		
			MOST LIKELY	MINIMUM	MAXIMUM
1	1	32	10	8	14
2	1	35.37	10	8	14
3	2	35.37	5	4	7
4	2	35.37	5	4	7
5	2	35.37	8	6	10

3.1 FINDINGS

The results of the runs for each scenario for dedicated and non-dedicated truck days are listed in Table 3-2 and 3-3, respectively. The results displayed are averages based on all 20 runs. A separate analysis of each dedicated truck day scenario follows.

3.1.1 SCENARIO 1

The system flows relatively smooth in scenario 1 on both dedicated and non-dedicated truck days as should be expected using the RFCC pre-implementation assumptions. The simulation run time is 8.81 hours. This is the amount of time it takes to process all freight. Therefore, it takes 8.81 hours from the time the first piece flows into the system to the time the last pallet exits the system. Given that it takes 1/2 hour travel time for freight to start arriving at the outbound side of the

Table 3-2. Dedicated Truck Day Simulation Results

	SCENE 1	SCENE 2	SCENE 3	SCENE 4	SCENE 5
SIMULATION RUN TIME (HOURS)	**8.81**	**9.28**	**12.82**	**12.03**	**8.79**
# PIECES TO CDSS	1032.40	25.55	1035.10	960.45	949.40
# PIECES RESORT	241.55	703.90	312.05	65.70	470.70
# INTERNAL PLTS MADE	558.35	557.60	1134.95	1064.50	698.30
% OF TIME RESOURCE UTILIZED					
UNITIZATION STATIONS					
STATION 1	84.92	89.19	56.70	53.02	79.63
STATION 2	58.56	61.52	39.10	36.04	54.01
STATION 3	57.69	60.58	38.49	39.22	58.94
STATION 4	43.06	45.28	28.77	31.61	47.38
STATION 5	43.89	46.00	29.29	33.21	49.75
STATION 6	49.67	52.19	33.11	33.27	49.82
STATION 7	62.12	65.24	41.45	41.27	62.10
STATION 8	83.12	87.37	55.53	53.17	79.85
AGV 1	66.24	62.67	92.78	92.47	82.95
AGV 2	69.36	65.73	96.71	97.08	87.31
OS2 SCANNER	84.17	85.46	58.49	56.04	81.92
SHRINK WRAPPER	48.25	45.19	62.36	62.88	58.56
BANDER	68.53	66.83	93.82	93.76	85.73
% OF TIME CONVEYOR SPACE CAPACITY UTILIZATION IS OVER 80%					
TRANSSHIPMENT & VENDOR CONVEYOR	3.37	28.33	19.40	0.00	18.12
HOST, TRANSSHIPMENT & VENDOR CONVEYOR	11.56	40.45	31.65	1.01	29.83
RESORT,HOST,TRANSSHIPMENT & VENDOR CONVEYOR	20.14	49.61	52.37	7.17	46.75
NUMBER OF PIECES BACKLOGGED					
TRANSSHIPMENT & VENDOR BACKLOG AVERAGE	2.30	30.70	8.40	0.00	4.70
TRANSSHIPMENT & VENDOR BACKLOG MAXIMUM AVERAGE	16.40	196.80	54.50	0.00	35.80

Table 3-3. Non-Dedicated Truck Day Simulation Results

	SCENE 1	SCENE 2	SCENE 3	SCENE 4	SCENE 5
SIMULATION RUN TIME (HOURS)	**8.99**	**9.59**	**13.10**	**12.33**	**8.95**
# PIECES TO CDSS	1053.15	1051.55	1048.80	989.15	985.30
# PIECES RESORT	362.35	886.15	485.10	135.75	646.95
# INTERNAL PLTS MADE	571.20	570.65	1160.00	1086.10	712.15
% OF TIME RESOURCE UTILIZED					
UNITIZATION STATIONS					
STATION 1	87.18	90.32	58.26	54.67	82.49
STATION 2	60.04	62.31	40.12	36.92	55.65
STATION 3	54.08	56.17	36.10	37.52	56.47
STATION 4	41.46	43.01	27.68	30.18	45.42
STATION 5	42.56	44.16	28.42	31.72	47.69
STATION 6	47.94	49.77	32.01	31.88	48.07
STATION 7	64.93	67.29	43.39	42.43	63.83
STATION 8	85.68	88.93	57.27	55.34	83.44
AGV 1	65.66	61.51	91.71	91.18	82.38
AGV 2	70.13	65.68	97.64	97.51	88.07
OS2 SCANNER	85.72	86.58	59.62	56.67	84.46
SHRINK WRAPPER	43.83	41.45	59.87	59.76	54.66
BANDER	66.08	61.43	90.50	89.60	81.86
% OF TIME CONVEYOR SPACE CAPACITY UTILIZATION IS OVER 80%					
TRANSSHIPMENT & VENDOR CONVEYOR	15.68	42.87	37.14	0.29	37.76
HOST, TRANSSHIPMENT & VENDOR CONVEYOR	26.70	52.21	47.51	4.20	49.49
RESORT,HOST,TRANSSHIPMENT & VENDOR CONVEYOR	38.40	60.20	59.09	19.68	65.35
NUMBER OF PIECES BACKLOGGED					
TRANSSHIPMENT & VENDOR BACKLOG AVERAGE	10.00	86.50	44.60	0.00	27.00
TRANSSHIPMENT & VENDOR BACKLOG MAXIMUM AVERAGE	72.40	415.57	226.20	0.40	129.50

terminal and consequently the shifts at the workstations near the end of conveyor could start 1/2 hour later than those on the inbound side, this time meets the RFCC 8 hour shift operation.

The only major area of concern in this scenario is the high utilization statistics for unitization workstations 1 and 8. These two workstations receive the two highest ranked customers and are responsible for palletizing approximately 40 percent of all internal pallets created. Since the workstations provide for some operational flexibility, changes and adjustments in operations could result in more efficiencies. For example, workstations 1 and 8 could be reduced to four lanes with the remaining lanes assigned to the other workstations. Another example could be to add one additional person to these workstations. This would reduce the manpower utilization levels to an acceptable level.

Also note that the OS2 scanner which is the scanner that sends pieces to CDSS or to the sortation scanner is running at a utilization rate of 84.17 percent. This indicates that forward of this point the package conveyor is utilized at near capacity.

In this scenario, the RFCC is capable of including the South Central region. However, this scenario uses a pallet unitization processing time of 32 seconds per piece and the most recent estimate of this workstation time is 35.37 seconds.

3.1.2 SCENARIO 2

This scenario differs from scenario 1 in that the unitization workstation processing time has increased from 32 seconds per piece to 35.37 seconds per piece. The simulation run time is 9.28 hours, approximately a 1/2 hour increase from scenario 1.

This is still an acceptable time because the 4 hour skeleton crew could pick up this excess workload.

The increase in unitization workstation times in Scenario 2 does, however, significantly impact the flow of pieces through the system. A bottleneck is created on the package conveyor due to the high volume of pieces meeting a lane full condition and being recirculated on the conveyor for resort. Because the resort package conveyor has priority over the transshipment, vendor and host conveyor, pieces sent around for resort cause the low priority conveyors, prior to this point, to become saturated. This is evidenced by the percent of time the lower priority conveyors are utilized at near capacity (greater than 80 percent). The number of pieces resorted needs to be kept to a minimum to prevent a backlog from being created on the lower priority conveyors. Again, the two lanes receiving the two highest ranked customers were responsible for the majority of pieces being sent to resort. As previously stated, the work station area is flexible to change and simple alternatives exist to reduce or alleviate the number of pieces sent to resort.

Also note that between scenario 1 and scenario 2, OS2 utilization increases by 1.3 percent in scenario two; however, the maximum backlog goes from 16.4 pieces to 196.8 pieces, a twelve fold increase. Clearly, 80 percent utilization of the OS2 scanner should be viewed as a warning indicator.

The increase in unitization times to 35.37 seconds should not hinder the RFCC from including the South Central region. While this scenario in and of itself is beginning to approach unacceptable levels, it is still a feasible workload. In addition, policy changes to the workstation configurations can prevent the flow of freight from backlogging.

3.1.3 SCENARIO 3

This scenario differs from scenario 2 in that the package size is increased from 1 foot to 2 feet and the most likely number of pieces per pallet is decreased from 10 to 5.

The simulation run time is 12.82 hours. This time is unacceptable. It is apparent that an increase in the piece size and a corresponding reduction in the number of pieces per pallet significantly impact the flow of material through the RFCC. For example, the amount of time the package conveyor is utilized to near capacity is affected by the increase in piece size. Moreover, the amount of time to process all freight (simulation run time) was increased drastically due to twice the number of internal pallets created (<u>note that a longer simulation run time artificially reduces all the statistics which are time dependent</u>.) These two factors greatly influence the flow of material though the RFCC on both the package and pallet conveyors. However, unlike the unitization workstations, there is no flexibility built into these areas.

The flow of freight through the RFCC is very sensitive to changes in average piece size and number of pieces per pallet. If the average piece size is 2 feet and the most likely number of pieces per pallet is 5, the RFCC <u>should not</u> include the South Central region in its local customer area.

3.1.4 SCENARIO 4

This scenario uses the same variables as scenario 3 except that in this scenario the amount of vendor freight was reduced from 2800 to 2380 pieces per day. This was considered an alternative since the estimates of vendor freight pieces have not changed for over four years.

The simulation run time was 12.03 hours. This is still an unacceptable time. While this alteration greatly reduces the stress on the package conveyor caused by the increased piece size, as in the previous scenario, the number of internal pallets created and the simulation run time is still very large. This indicates that the pallet conveyor was unable to process the pallets fast enough.

Even with a 15 percent reduction in the estimates of vendor freight, the RFCC <u>should not</u> include the South Central region if the piece size is 2 feet and the number of pieces per pallet is 5. Again, this scenario shows the impact that the number of pieces per pallet and the corresponding number of internal pallets created has on the pallet conveyor system.

3.1.5 SCENARIO 5

This scenario differs from the previous scenario by increasing the most likely number of pieces per pallet from 5 to 8. The piece size remains at 2 feet.

The simulation run time is 8.79 hours. As in scenarios 1 and 2, this is an acceptable run time.

Increasing the number of pieces per pallet and reducing the amount of vendor freight, reduces considerably the strain on the pallet conveyor. The number of internal pallets created is 698.30 which the pallet conveyor seems to be able to accept. However, the AGVs utilization is 82.95 percent and 87.31 percent of the 8.79 hours of simulation run time. Thus, the AGVs are still heavily utilized moving the internal pallets.

Also, it appears that the strain from the pallet conveyors is pushed back to the package conveyor as evidenced by the percent

of time the low priority package conveyors are utilized at near capacity.

As in scenario 2, this scenario is beginning to approach unacceptable levels. It may still be a feasible workload, but more caution should be used in accepting this scenario. Not only are the OS2 scanner and the low priority conveyors being highly utilized as in scenario 2, but there is also an additional high utilization of the AGVs. Also, the justification for reducing the vendor freight may or may not be sound. Since these variables are not flexible like the pallet unitzation processing times, no recommendation is made to include the South Central region based on this scenario.

3.2 CONCLUSIONS

Scenario 1 and Scenario 2 indicate the RFCC can accommodate the South Central region. Scenario 3 and Scenario 4 indicate the RFCC can not accommodate the South Central region.

The overall results of the simulation reveal three factors that significantly impact the flow of material through the RFCC. These factors are the pallet unitization workstation process times, the size of the pieces flowing through the RFCC, and the number of pieces placed on a pallet at the pallet unitization workstations.

The flow of freight through the RFCC is sensitive to changes in the unitization workstation times. However, policy changes in the unitization workstation configuration and operation can compensate for changes in workstation time, thus not impacting the flow of freight. For example, stationing two people at a workstation will reduce the time needed to clear the lane and build a pallet. Because of its flexibility, this factor should

not hinder expanding the local customer area to include the South Central RFCC region.

The size of a piece has an impact on the number of pieces per pallet. With the RFCC still in the testing phase, it is very difficult to obtain accurate data for these two factors. Since these factors are not adaptable to policy changes within the freight terminal, the actual piece size and number of pieces per pallet should be verified before a final decision is made to include the South Central RFCC region.

SECTION 4
RECOMMENDATIONS

Based on analysis using available data and sensitivity analysis, with respect to piece size and number of pieces on a pallet, we recommend that a decision to include the South Central region be delayed until accurate data is obtained on these two important variables.

- If the average piece size is 1 foot or less and the average number of pieces per pallet is greater than 10, we recommend including the South Central region as part of the RFCC local customer area.

- If the average piece size is 2 feet or greater and the average number of pieces per pallet is 5 or less, we do not recommend including the South Central region as part of the RFCC local customer area.

- If the average piece size is between 1 and 2 feet and/or the average number of pieces per pallet is between 5 and 10, we recommend that the simulation be rerun and that the results be used as a basis for determining whether the South Central RFCC region should be included as part of the RFCC local customer area.

APPENDIX A

LANE ASSIGNMENT GUIDELINES

APPENDIX A
LANE ASSIGNMENT GUIDELINES

The following list defines the Key Elements\Resources available:

- Sortation Lanes
- Conveyors
- Scanners
- Transfer Cars
- Personnel

Of these Key Resources, Which can you control and how?

- Assuming that Engineering Design is relatively fixed conveyor speeds, scanning rate, and que selection rule by the transfer carts can not be altered. Sortation appears to be the only key area in which the decision maker can influence the system without major software/engineering rework.

The Constraint

- Sortation - Scheduling Customers to Lane Assignment

How do you exploit this constraint?

- One KEY RULE governs the process. Top customers in terms of the number of pieces processed by the RFCC are assigned lanes adjacent to the transfer carts at each station.

Resources which have slack, must be utilized to "feed" the limiting constraint at the maximum throughput.

- Consider utilizing two workers at palletization stations where the top two customers are processed. One worker focuses on the top customer at the station, while the second worker focuses on the remaining lanes.

- Another consideration would be to go with 69 top customers, and provide the top two customers with two lanes each. This option is especially useful if the potential for resort is high. Your buffer doubles from 20ft of lane space to 40ft.

- Finally, consider the purchase of wireless head microphones for the workers at each pallet station. This has the potential for allowing the workers on the North and South Lanes (on separate frequencies) to communicate their lane status to each other and the supervisor. In this way, the transfer cart can be prioritized.

- The lane configuration scheme utilized in the RFCC simulation is on the following two pages.

Table A-1. Lane Configuration

CUST#	NORTH LANES		SOUTH LANES	CUST#
			LN 238	1
			LN 237	59
			LN 236	71
			LN 235	76
			LN 234	70
2	LN 283		LN 233	58
61	LN 282		LN 232	65
55	LN 281		LN 231	62
57	LN 280		LN 230	77
64	LN 279		LN 229	78
60	LN 278		LN 228	3
56	LN 277		LN 227	47
54	LN 276		LN 226	38
4	LN 275		LN 225	37
63	LN 274		LN 224	50
49	LN 273		LN 223	52
51	LN 272		LN 222	40
53	LN 271		LN 221	29
30	LN 270		LN 220	45
22	LN 269		LN 219	39
48	LN 268		LN 218	5
67	LN 267		LN 217	12
6	LN 266		LN 216	36

Table A-1. Lane Configuration (Continued)

11	LN 265		LN 215	35
21	LN 264		LN 214	46
14	LN 263		LN 213	31
28	LN 262		LN 212	27
19	LN 261		LN 211	20
13	LN 260		LN 210	23
32	LN 259		LN 209	7
8	LN 258		LN 208	10
41	LN 257		LN 207	34
43	LN 256		LN 206	33
26	LN 255		LN 205	42
17	LN 254		LN 204	44
9	LN 253		LN 203	25
24	LN 252		LN 202	18
15	LN 251		LN 201	16

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This is an analysis to determine if the DDRC RFCC located at Defense Distribution Depot Memphis, Tennessee (DDMT) can accommodate increases in throughput and workload from expanding its local customer area to include pooled freight destined for the South Central RFCC region (Texas, Oklahoma, Kansas, and New Mexico). A simulation model is used to determine if the RFCC can accommodate these increases. The results of the simulation reveal three factors that significantly impact the flow of material through the RFCC. They are the pallet unitization workstation process times, the size of the pieces flowing through the RFCC, and the number of pieces placed on a pallet at the pallet unitization stations. Any problems encountered with the flow of freight through the RFCC caused by the unitization workstations can be accommodated by adjusting policies and should not hinder expanding the local customer area to include the South Central region. Piece size and number of pieces per pallet are not adaptable to policy changes within the freight terminal. With the RFCC still in a testing phase, accurate data is not yet available for piece size and number of pieces per pallet.

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